CTD Data Acquisition Program for a Guildline Mark IV Probe Using a HP9825 Microcomputer System

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Les établissements des Sciences et levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports en décembre 1981. Une liste complète de ces publications figure dans le volume 39, Index des publications 1982 du *Journal canadien des sciences halieutiques et aquatiques*. La série actuelle a commencé avec la publication du rapport numéro 1 en janvier 1982.

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ABSTRACT

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A computer program was developed on a HP9825 microcomputer for oceanographic data collection using a Guildline CTD system. The program provides full-rate binary data logging to 9-track computer tape, real time printout of calculated data and analysis of data quality. Details of input and output data and all program operations are described. A complete description of operating procedure is also given.

RÉSUMÉ

Lang, C. C. 1985. CTD Data Acquisition Program for a Guildline Mark IV Probe using a HP9825 Microcomputer System. Can. Tech. Rep. Fish. Aquat. Sci. 1371: v + 52 p.

On a mis au point un programme sur micro-ordinateur HP9825 pour la collecte de données océanographiques à l'aide d'un système CTP Guildline. Le programme permet l'enregistrement complet de données binaires sur bande à neuf pistes, l'impression en temps réel des calculs et l'analyse de la qualité des données. Les détails des donneés d'entrée et de sortie ainsi que toutes les opérations du programme sont présentés, y compris une description complète des procédures d'exploitation.

1. PROGRAM DESCRIPTION

1.1 INTRODUCTION

The computer program CTD LOGGER (Version 3.0) described in this manual was developed to increase data collection capabilities using a microcomputer interfaced with a Guildline Mark IV CTD (conductivity, temperature, depth) system. This system samples at the rate of 25 samples per second. Analog signals from the sensors are continuously digitized and transmitted from the sea probe to the shipboard CTD central unit. The data are then reformatted and output through one or more optional interfaces. Previously, this measurement data had been simply recorded on audio cassette tape and plotted on an analog XYY recorder. Occasionally a microcomputer was used to calculate salinity and density values. This system had proven unsatisfactory because of lengthy delays in recovering the data for post-cruise processing, hardware problems with the audio tape interface, and insufficient data quality evaluation during the cruise.

The computer program provides full-rate binary data logging to 9-track computer tape, real time printout of calculated data at selected depths, and real time analysis of data quality. The advantages offered over the previous system include the following:

1) The operator can continually adjust the measurement procedure for optimal data quality and speed of collection.

2) The oceanographer can safely modify the cruise program as necessary to maximize information return.

3) Timely and complete reconstruction of the measurements during post-cruise processing is possible on virtually any computer system.

The program has been extensively field-tested and is now used routinely on oceanographic cruises without need for programmer support. The programming language used is HPL, an interpreted language (much like BASIC) for the Hewlett Packard (HP) 9825 desktop computer. The program (with minor modifications) has also been run in HPL on Hewlett Packard's new series 200 microcomputer.

This manual was prepared to aid the user in evaluating and operating the program. It describes the CTD system, the program itself, and operating procedures. The reader is assumed to have a reasonable understanding of oceanographic data collection techniques and analog and digital electronics. However, operation of the program requires little knowledge of the technical details.

1.2 FUNCTIONAL DESCRIPTION

The program as described in this manual provides the following vertical CTD profiling support functions:

(a) Full rate Mark IV data logging on IBM compatible nine-track magnetic tape.
(b) Real time operator control of data logging (RECORD/MONITOR).
(c) Real time sampling and conversion of the measured pressure, conductivity ratio, and temperature parameters into engineering units.
(d) Real time maintenance of the system status and data error indicators.
(e) Real time calculations of sigma-t (density) and salinity parameters on operator command and at pre-selected depths.
(f) Generation of a printed summary report of each profile.

1.3 PERFORMANCE SPECIFICATIONS

Data input rate (Mark IV)	400 words/sec (25 messages/sec)
Average data logging rate	800 bytes/sec (25 messages/sec)
Magnetic tape utilization rate	MONITOR: 0 ft/min RECORD: 3.4 ft/min (approx)
Data sampling (for conversions and calculations)	16% of input (4 messages/sec)
Error checking and conversion to engineering units	16% of input (4 messages/sec)
Depth calculation frequency	4/sec (max)
Density calculation frequency	1/sec (max)
Salinity calculation frequency	1/sec (max)
System data delay (from measurement to operator display)	1.2 sec (approx.)

1.4 HARDWARE CONFIGURATION

The hardware configuration for which this computer program was developed, includes the Mark IV oceanographic measurement system, several shipboard support systems, as well as the computer system itself. Figure 1 illustrates the system boundaries.

Equipment specifications are provided in the Appendices and detailed equipment descriptions are available from the manuals listed in the References section of this manual.

Functional descriptions of the major equipment components are provided below.

1.4.1 Measurement System Components

The Mark IV measurement system measures pressure, temperature and conductivity ratio (P, T, and C) while descending or ascending through a column of seawater to a maximum pressure of 6000 decibars. The Guildline probe is usually mounted in a Rosette sampler also used to collect Niskin bottle water

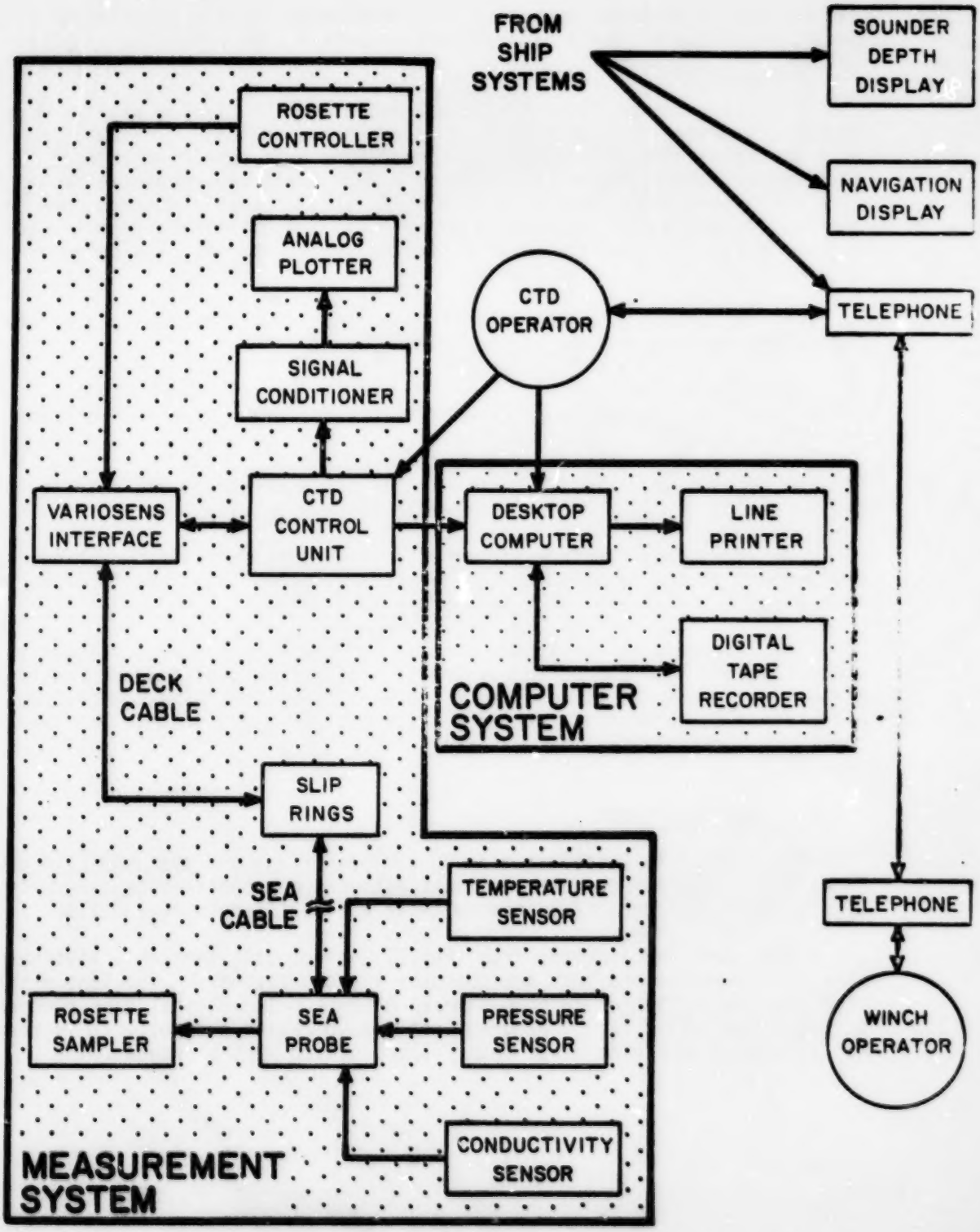

FIGURE I. HARDWARE CONFIGURATION

samples for calibration purposes. The measurement system consists of a sea probe, a CTD control unit, a Variosens interface, and a Rosette sampling system.

The sea probe performs the actual measurements. Analog signals with high dynamic range are derived from each of the three sensors. Pressure is measured by a strain gauge type transducer, temperature by a copper resistance thermometer, and conductivity ratio by a four electrode conductivity cell. Each of these signals is digitized with 22 bits of resolution and encoded as two 12 bit data words (supression and offset). Digital data from the sea probe is continuously transmitted over a simplex serial channel (via conductor cable) to the shipboard CTD control unit.

The control unit monitors the channel and formats the sea probe data for output through one or more optional interfaces:

1) Stereo audio tape
2) Low resolution analog voltages suitable for driving an XYY recorder
3) TTL compatible 16 bit parallel data

It also decodes approximately one-third of the data stream and outputs the three results (P, T, and C) to its numerical LED displays.

The Variosens interface simply acts as a means of interconnecting the measurement system and the Rosette sampling system. This interface can be used with other optional equipment to measure turbidity.

The Rosette sampling system consists of the Rosette sampler, Rosette controller and interconnecting wiring. This system is used periodically to collect water samples as required for CTD calibrations. The Rosette sampler also serves as a physical carrier for the sea probe and protects it from damage should it accidentally hit the sea bottom.

1.4.2 Computer System

The program is loaded from an HP data cartridge and executed by a Hewlett Packard 9825 desktop computer equipped with three interfaces, a line printer, a digital tape recorder and system software as specified in Appendix 2.

Input data are accepted from the CTD control unit through a sixteen-bit parallel interface and from the operator via the keyboard. The line printer is used only for output of Profile Summary Reports. The digital tape recorder is directly controlled by the program (not the operating system). It is reserved for storage of the nine-track data files produced by the program.

2. INPUT DATA

2.1 MARK IV DATA

Data are transmitted from the CTD control unit to the computer as sixteen-bit binary words (negative-true logic) at the rate of 400 words/sec. Each word has two components: the four high order bits contain a channel address (0 to 15), while the twelve low order bits contain the actual data.

A data message is a group of sixteen successive words with channel addresses zero through fifteen. Each message contains the measurement data from one complete scan of the sea probe's sensors. The channel assignments within each message are:

0	Undefined
1	Negative Voltage Reference (-Vref)
2	Pressure Suppression (PΔ)
3	Pressure Offset (Po)
4	Temperature Supression (TΔ)
5	Temperature Offset (To)
6	Conductivity Supression (CΔ)
7	Conductivity Offset (Co)
8..15	Undefined

Channels 8 through 15 are usually either wired to repeat the information in channels 1 through 7 or reserved to accommodate signals from optional sensors. More detailed information is available in the system's operating manual (see references).

2.1.1 Sync Error

Data transmission errors which are internal to the Mark IV system can cause the control unit to transmit sequences of words whose channel addresses do not count in the normal fashion (0 through 15). An occurrence of such a sequence is called a synchronization (sync) error. This program cannot decode such sequences but does record them in the output data file.

2.1.2 Voltage Reference Error

Measurement subsystems internal to the sea probe require the supply of two precision voltage reference sources: +Vref and -Vref. These voltages are derived and regulated automatically within the probe itself. In every scan cycle of the probe's sensors, -Vref is also measured, and its value is transmitted in channel 1 of each message. A message which contains a -Vref measurement which is outside the manufacturer's specified tolerance range causes the ERROR lamp on the CTD control unit to light. An occurrence of such a message is called a voltage reference (Vref) error. This program does not decode such messages but does record them in the output data file.

2.2 PROFILE IDENTIFICATION DATA

The Profile Identification Data is supplied by the operator (via the computer keyboard) immediately prior to the collection of the Mark IV profile data. This information is used to identify the Profile Summary Report and Nine-track Data File produced for the profile (See section 3, OUTPUT DATA).

Operator entry instructions are provided in section 6. The required input data are: Ship #, Trip #, Station #, Profile #, Latitude, Longitude, Sounder depth, Date, and Time.

3. OUTPUT DATA

3.1 NINE-TRACK DATA FILES

Each execution of the program (each profile) produces a new data file on the nine-track tape. Each file consists of a variable number of data blocks followed by an end-of-file mark. The last file on a tape is followed by an end-of-data mark which is two consecutive end-of-file marks.

The tapes produced are IBM-compatible, 1600 bpi phase-encoded (PE) format, with a block size of 3200 bytes. The tapes are intended for archival storage and subsequent detailed analysis on a larger computer system.

Data tape is utilized at the rate of approximately 3.4 ft/min during profile recording. Thus, a 200 metre profile at a sea probe speed of 40 m/min would require about 17 ft of data tape (i.e. about 240,000 bytes of data). Nominally, a 2400-ft tape reel can log 10 hours of profiling.

3.1.1 Data File Content

The first block of a data file contains a header which is used to identify the file. Included is information such as profile number, date, time and location. Appendix 3 is a formal specification of the header format.

Subsequent data blocks in the file contain duplicates of the unprocessed Mark IV words (negative-true logic), as received from the CTD control unit during the course of the profile. However, as the recording medium is byte-oriented, each individual input word is recorded as two bytes (high order byte first). The last data block in a file is padded, if necessary, with the ASCII line feed code (decimal 10).

3.1.2 Processing Considerations

When processing the Mark IV data from these files, two bytes are read to form a sixteen-bit, negative-true, data word. This word is then complemented yielding a sixteen-bit integer in conventional positive-true representation. Note that when processing reaches the ASCII pad characters in the last data

block of the file, this interpretation scheme will return integers whose channel address is 15 and data value is 1525 (decimal).

Integer:	11110101	11110101
Data word:	00001010	00001010
ASCII:	<LF>	<LF>

3.2 PROFILE SUMMARY REPORT

Each execution of the program (each profile) produces a profile summary report as a characterization of the nine-track data file logged during the profile. This printed report is composed of three sections: profile identification, specific data measurements and the post-profile status; each of which is described below. Appendix 4 is a sample of a summary report.

3.2.1 Profile Identification

The information in this section serves as a label for the summary report. Included are the ship, trip and station codes, the profile number, position coordinates, estimated (sounder) depth, date, and time. Also, the calibration corrections and probe I.D. are printed here.

3.2.2 Measurements

Each line in this section of the summary report can take one of two formats; the automatic record format or the demand record format. Automatic record lines are triggered by the occurrence of specific pre-programmed events, whereas demand record lines are triggered manually by the operator.

During the profiling, an automatic record line is printed as the sea probe reaches each depth value specified in the depth trigger table[1]. The information printed consists of the depth, temperature, salinity and sigma-t values associated with a single Mark IV data message input.

A demand record line is printed on command from the operator. This feature is provided to facilitate the collection of calibration water samples with the Rosette sampling system. Immediately after tripping the sampling mechanism, the operator requests several demand records. Although the print format is similar to that of the automatic record line, the conductivity ratio parameter is included and all of the values are printed with full resolution and without calibration corrections. Refer again to the sample profile summary report (Appendix 4).

[1]This table of depth values can be modified by the user. See section 5.

3.2.3 Post-profile Status

This final section of the Summary Report includes: input and output data quantities, program performance measurements, and summarized results of the error analysis of input samples. This information provides the operator with a printed report which reliably characterizes the profile data quantity and quality immediately after data collection.

Descriptions of these output parameters are provided below. Section 6.4 discusses data quality assessment with respect to these parameters.

Input and Output Data Quantities

(a) Bytes Input: total number of bytes of binary Mark IV input data received from the Oceanographic Measurement System.

(b) Bytes Recorded: total number of bytes of binary Mark IV data contained in the Nine-track data file.

Program Performance Measurements

(a) Points Sampled: size of the input sample which was subjected to error analysis. This parameter is expressed as the number of potential messages and as a percentage of input data.

(b) Samples Blocked: amount of input data which normally could have been included in the input samples but, because of processing overload, was not. Expressed as the number of potential messages.

The 'Samples Blocked' parameter is useful for evaluating the performance of a user-generated 'working version' of the program. See section 5 (Program Configuration) for details.

3.2.4 Error Summary

A portion of the input data (nominally 16%) is sampled and subjected to various error checks. These checks serve two purposes: (1) to filter out illegal or questionable data before performing conversions and calculations; and (2) to enable the program to quantify these data errors in a manner which is useful to the operator/user for data quality assessment and system diagnosis.

Error checks are performed sequentially in the order listed below. A data message disqualified by one of the checks is not subjected to any subsequent check. Thus, the data error categories are mutually exclusive.

There is an Error Summary output parameter for each of the error categories; its value indicates the portion of the sampled data which was disqualified because of the particular error type. The categories are:

(a) Sync; illegal input word sequence (see section 2.1)

(b) Vref; illegal voltage reference value (see section 2.1)

(c) P Rate; rate of change of the pressure parameter exceeds its pre-set limit (see section 5.2)

(d) T Rate; rate of change of the temperature parameter exceeds its pre-set limit (see section 5.2)

(e) C Rate; rate of change of the conductivity ratio parameter as it exceeds its pre-set limit (see section 5.2).

3.3 STATUS RECORD

The status record is composed of six data fields which collectively reflect the current operating status of the program. Its function is to give information to the operator only.

After each attempt to decode a Mark IV input message, a new status record is generated and immediately output to the computer display. The six data fields of the status record are:

(a) MODE : current operating mode (record or monitor).

(b) DEPTH : current depth of sea probe (metres).

(c) SYNC : cumulative count of sync errors detected during the profile.

(d) VREF : cumulative count of vref errors detected during the profile.

(e) RATE : cumulative count of rate errors detected during the profile.

(f) SAMPLE : current sample number.

Since each input message is decoded in a fraction of a second, the status record display appears as a continuous display of the six dynamic variables. The display format is illustrated in Fig. 2.

4. DATA PROCESSING METHOD

4.1 DATA LOGGING

Input data are processed in blocks of 400 words, each consisting of approximately one second of data. A direct memory access (DMA) technique is

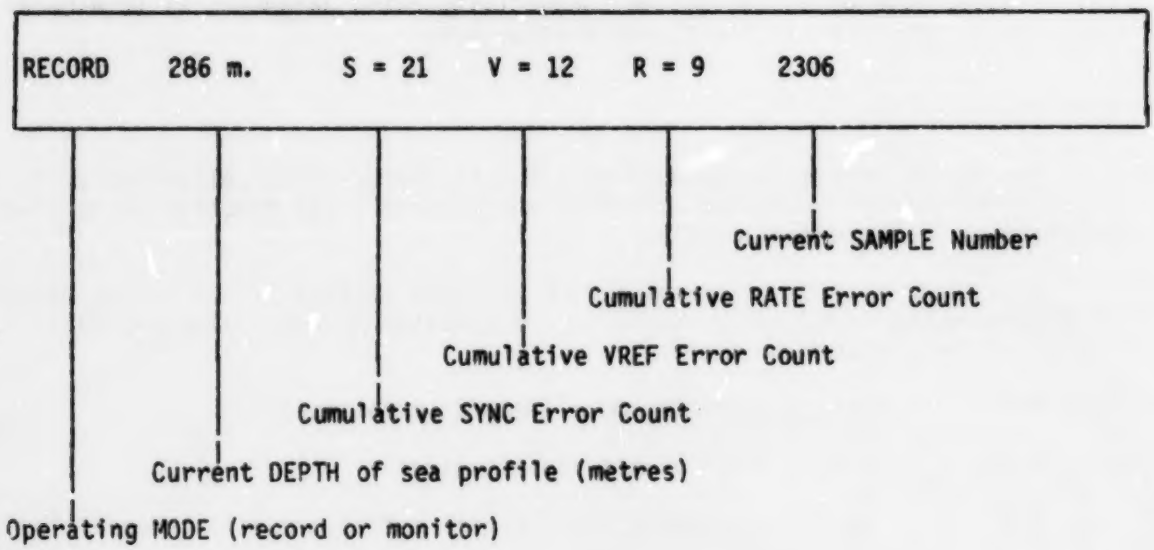
RECORD 286 m. S = 21 V = 12 R = 9 2306
Current SAMPLE Number
Cumulative RATE Error Count
Cumulative VREF Error Count
Cumulative SYNC Error Count
Current DEPTH of sea profile (metres)
Operating MODE (record or monitor)

Fig. 2. Sample of status record display.

used to transfer each block of data into computer memory. This technique requires minimal supervision from the computer's central processor unit and thus allows processing of one data block concurrently with input of the next data block.

An exact copy of each input data block is transmitted to the nine-track tape recorder immediately after its input is completed (if the program is in Record mode). The input data block is then used to generate four single-message buffers which are separated in time by 250 msec. These buffers will subsequently be subjected to error checks, data conversions, and calculations as outlined in Sections 4.2, 4.3 and 4.4.

4.2 ERROR DETECTION

Single-message data buffers are delivered to Error Detection from Data Logging as described in Section 4.1. Refer to Section 2.1 for a description of the Mark IV input data.

4.2.1 Message Extraction (SYNC Check)

The extraction of measurement data from a data buffer entails three operations: binary inversion (to give positive-true logic), separation of channel address and data, and verification of proper channel address sequence (0 through 15). Note that because 'single-message data buffers' are not aligned on message boundaries, each buffer must contain at least 31 consecutive data words.

The data buffer is forward searched for a channel 0 data word (if it is not found within the first 16 words, a SYNC error is registered). The Mark IV data message is then reconstructed from the twelve data bits of the next fifteen words in the data buffer. Finally, the channel address of the fifteenth word is checked. If it is not channel 15, a SYNC error is registered.

4.2.2 Vref Check

If the data message has not been disqualified by a SYNC error, channel one is checked for a valid voltage reference word. Valid voltage reference is defined as -3.983 ± .077 volts. If channel one binary data is not XX1001XXXXXX, a voltage reference error is registered (X represents "don't care").

4.2.3 Rate of Change Checks

If the data message has not been disqualified by a SYNC or VREF error, it is converted to engineering units as described in Section 4.3 Data Conversions. The converted and corrected values of P, T, and C are compared to the values

for the previous data message. If the rate of change of a parameter exceeds its alarm limit, a P rate, T rate, or C rate alarm is registered. Note that the checks are done in the order P, T, C and that the error categories are mutually exclusive. If a data message is disqualified by any check, it is not subjected to any subsequent checks.

These checks are used to detect data transmission errors (beyond SYNC errors) in an effort to gauge data quality. Section 5.2 discusses the choice of appropriate alarm limits.

4.3 DATA CONVERSIONS

4.3.1 Guildline Recombination Method

$P_m = (FSP) * G(P_o, P_\Delta)$ (FSP = Full-scale pressure)

$T_m = G(T_o, T_\Delta)$

$C_m = G(C_o, C_\Delta)$

Two 12-bit binary words (supression word and offset word) for each of the three parameters are combined to give real number representations of the measurements. The recombination Method G is described by Guildline. An assessment of this method with a recommendation for a new method is given in Appendix 5.

4.3.2 Calibration Corrections

$P = P_m + P_{offset}$ (P_{offset} = Constant ≅ 0.0 bar)

$T = T_m + T_{offset}$ (T_{offset} = Constant ≅ 0.0 °C)

$C = C_m * C_{scaling}$ ($C_{scaling}$ = Constant ≅ 1.00)

The measured parameters are corrected to account for known sensor drift since the last electronic calibration. Note that the calibration offset should not be confused with the binary offset word.

4.4 OCEANOGRAPHIC CALCULATIONS

4.4.1 Depth

The depth approximation used by the program is

$Z = kP$ for Z in metres,
P in bars,
k = 10

or, the depth parameter is actually the pressure expressed in decibars.

The accuracy of this parameter is dependent on three factors:

1) accuracy of the pressure measurement (±0.15% of full scale);

2) average density of the column of seawater above the sensor;

3) local acceleration of gravity (a function of both latitude and depth).

Table 4 illustrates that for pressures (0 to 100 bar) and mean in situ densities (1015 to 1035 kg/m^3) the approximation error is less than 2%.

More accurate methods of converting pressure to depth are available (e.g. Saunders and Fofonoff, 1976) but are not used in this system because of the limited accuracy of the pressure measurement. Furthermore, the pressure channel is known to be affected by hysteresis and temperature but these effects have not been quantified.

4.4.2 Salinity

The salinity calculation performed by the program is based on the practical salinity scale, 1978. The algorithm used is valid over ranges of temperature (-2 to 35°C), pressure (0 to 1000 bars), and practical salinity (2 to 42) in the world oceans.

The practical salinity definition was developed to enable all oceanographers using CTD instruments to report their observations in a consistent manner. The salinity scale definition and computational algorithm are described in detail by Lewis 1980 and UNESCO 1981. A brief description is provided below.

A precisely specified solution of potassium chloride was chosen as the reproducible electrical conductivity standard. It yields a conductivity ratio of unity at 15°C with respect to North Atlantic seawater with salinity of 35 ppt on the old salinity scale (equivalent to a chlorinity of 19.370 ppt). Note that a conductivity ratio of unity at 15°C and one standard atmosphere of pressure corresponds, by definition, to a practical salinity exactly equal to 35.

Whereas the old salinity scale was based on a conductivity-chlorinity relation using natural seawaters, in the new scale the standard seawater used was diluted by weight with distilled water or evaporated to obtain other salinity values. This procedure ensures the constancy of composition of this seawater over the salinity range of interest. The salinities obtained on this scale are referred to as practical salinities and are reported as dimensionless quantities. All seawaters having the same conductivity ratio, temperature and pressure have the same practical salinity. Cholorinity is to be regarded as a separate, independent variable in describing the properties of seawater.

The measured conductivity ratio (C) is the ratio of the in situ conductivity to that of standard seawater at S = 35, T = 15°C, and P = 0 bar

(where P is the pressure above one standard atmosphere). To permit the calculation of practical salinity, C is factored into three parts;

$$C = R_p * r_t * R_t$$

where R_p is the ratio of the in situ conductivity of the same sample at the same temperature but at P = 0; r_t is the ratio of the conductivity of reference seawater, having a practical salinity of 35, at temperature T, to its conductivity at T = 15°C; and R_t is the ratio of the conductivity of seawater, at temperature T, to the conductivity of seawater of practical salinity 35 at the same temperature (both at P = 0). In short,

$$R_p = \frac{\sigma(S,T,P)}{\sigma(S,T,0)}$$

$$r_t = \frac{\sigma(35,T,0)}{\sigma(35,15,0)}$$

$$R_t = \frac{\sigma(S,T,0)}{\sigma(35,T,0)}$$

$$C = \frac{\sigma(s,T,P)}{\sigma(35,15,0)} = \frac{\sigma(S,T,P)}{\sigma(S,T,0)} * \frac{\sigma(35,T,0)}{\sigma(35,15,0)} * \frac{\sigma(S,T,0)}{\sigma(35,T,0)}$$

It has been found that R_p and r_t can be expressed as functions of the numerical values of the three measured parameters P, T, and C, as follows

$$R_p = \frac{1 + P(e_1 + e_2P + e_3P^2)}{1 + d_1T + d_2T^2 + (d_3 + d_4T)C}$$

and

$$r_t = c_0 + c_1T + c_2T^2 + c_3T^3 + c_4T^4$$

Thus, a knowledge of R_p and r_t allows the calculation of R_t (based on the factoring of C) with

$$R_t = \frac{C}{R_p * r_t}$$

and finally, the practical salinity of the seawater sample is given by

$$S = a_0 + a_1R_t^{1/2} + a_2R_t + a_3R_t^{3/2} + a_4R_t^2 + a_5R_t^{5/2} + \Delta S$$

where

$$\Delta S = \frac{(T-15)}{1 + k(T-15)} (b_0 + b_1R_t^{1/2} + b_2R_t + b_3R_t^{3/2} + b_4R_t^2 + b_5R_t^{5/2})$$

The values of the required constants are listed in Appendix 6.

4.4.3 Sigma-t

The sigma-t calculation used in the program is based on the international equation of state of seawater, 1980 (UNESCO 1981). It is valid over ranges of temperature (-2 to 40°C), pressure (0 to 1000 bars) and practical salinity (0 to 42).

The oceanographic sigma-t (not to be confused with electrical conductivity, sigma) of a seawater sample is related to its density (kg/m^3) at one standard atmosphere (P = 0 bar) by

$$\sigma_t = \rho(S,T,0) - 1000$$

$\rho(S,T,0)$ differs from the *in situ* density $\rho(S,T,P)$ in that the effects of compressibility are ignored. It is given by the equation

$$\rho(S,T,0) = \rho_w + (b_0 + b_1T + b_2T^2 + b_3T^3 + b_4T^4)S + (c_0 + c_1T + c_2T^2)S^{3/2} + d_0S^2$$

where ρ_w is the density of reference pure water obtained from

$$\rho_w = a_0 + a_1T + a_2T^2 + a_3T^3 + a_4T^4 + a_5T^5$$

T and S are respectively, temperature (°C) and practical salinity (see section 4.4.2). The values of the constants used are listed in Appendix 7.

5. PROGRAM CONFIGURATION

The program as delivered (CTD LOGGER Version 3.00) is the Master Version from which various working versions of the program may be generated. This allows the user to modify the program to account for:

(1) Scaling and calibration differences between specific sea probes and sensors;

(2) A desire to change the pre-programmed depths associated with the printed parameter records in the profile summary report;

(3) A desire to change the definition of a data rate alarm.

Extensive program modifications beyond those described here should be undertaken only after careful study of the program structure and its timing requirements.

To generate a new working version of the program:

(1) Read the applicable section(s) below;

(2) Edit the Master Version of the program, changing the particular program instructions as directed;

(3) Record the new working version on a data cassette;

(4) Test the new program.

5.1 PROBE PARAMETERS

The subroutine "SET CO CONSTANTS" is executed during program initialization. Its function is to assign values to the program's array variables F[1..7], and N[0..3]. Subsequently, during data acquisition, these values are used to convert the sea probe data measurements from binary values to engineering units (by subroutine "CO"). Also, the string variable F$[1..9] is provided to allow the user to identify the probe. This nine character field is printed on the profile summary report as the "Probe ID".

5.1.1 Full Scale Pressure

The full scale pressure associated with a particular pressure sensor should be placed in F[7]. The default value is 100 bar.

5.1.2 Calibration Adjustments

Each of three measured parameters (P, T, and C) is adjusted to account for user-supplied calibration corrections as follows:

$P = P_m + P_{offset}$ (default $P_{offset} = 0$ bar)

$T = T_m + T_{offset}$ (default $T_{offset} = 0$ °C)

$C = C_m * C_{scaling}$ (default $C_{scaling} = 1$)

The associated program variables are respectively F[4], F[5], and F[6].

5.2 RATE ALARMS

The rate alarm limits are indicated by the values of three constants in the subroutine "GT" (lines 166 to 168). The default alarm conditions are:

$|\Delta P| > 50$ bar

$|\Delta T| > 15°C$

$|\Delta C| > 0.5$

Because these parameters are normally sampled at 250 millisecond intervals, the above change-in-value limits correspond to rate of change limits of 200 dbar/sec, 60°C/sec and 2.0 per second. These default limit values are rather high and therefore will detect only severe hardware malfunctions and a subset of possible data transmission errors.

If desired, the user may change these alarm limits to lower values and thereby detect more subtle hardware problems, a larger class of data transmission errors and perhaps even large thermoclines. However, careful judgement must be exercised and adequate testing should be carried out to ensure that the value(s) chosen are not too low. Note that when the change in value of a parameter is calculated the corresponding change in time is unknown (in the presence of SYNC or VREF errors it may be other than 250 milliseconds). Appendix 5 discusses the hardware-imposed rate-of-change limits.

5.3 DEPTH TRIGGER TABLE

The subroutine "SET PROFILE TRIGGERS" is executed during program initialization. Its function is to assign values to the programs "r variables" (r0, r1, r2, . . .). Subsequently, during data acquisition, these values determine the specific depths at which a parameter record is written to the profile summary report.

Practically any depths can be assigned to these variables. However, observe the following restrictions:

(1) depths must increase with increasing r number.
(i.e. r0 < r1 < r2 . . .)

(2) highest numbered r variable must contain a depth which will never be reached.
(e.g. default is r35 = 9999 m)

(3) lowest numbered r variable must be r0.

6. OPERATION

6.1 INSTALLATION

Install the Oceanographic Measurement System in accordance with the manufacturer's operator manuals listed in the References. The equipment should be located in a dry room. Most components are installed in a standard 19 inch equipment rack (1.5 m high) which is located within 2 metres of the computer and printer. Voice communication between the CTD and winch operators is necessary. Refer to Fig 1.

6.1.1 AC Power Requirements

The computer, printer, tape drive, and CTD control unit are supplied via the specified power bar. A supply of 115 volts ± 10%, 60 Hz., 15A is required for the power bar. Maximum power required is approximately 1000 watts.

Note that computer system performance is erratic with insufficient voltage regulation, voltage spikes, or improper grounding. Ensure that 115 V ± 10% can be maintained.

6.1.2 Computer Interfacing

(a) Parallel I/O - To BINARY OUT port of the CTD control unit.
- Select code = 2.

(b) Printer - To rear port of the 9866B printer.
- Select code = 6.

(c) HPIB - To rear port of tape drive.
- Select code = 7.
- Tape drive addresses: control = 08, data = 09 (rear switches 1 through 7 = 0000100).

6.1.3 Computer System Start-up

(a) With the computer off, turn on the CTD control unit, printer, and tape drive. Mount a nine-track data tape.

(b) Ensure that the three interface cards are fully seated in the slots at the rear of the computer. DO NOT INSERT OR REMOVE INTERFACE CARDS WHILE THE COMPUTER IS ON!

(c) Turn on the computer. The display should contain the lazy-T character (τ).

(d) Insert the HP data cartridge containing the CTD LOGGER program.

(e) Determine the track number and file number where the program is stored on the cartridge and load the program.

For track 1, file 3 (for example), key in the sequence:
trk1; ldf3 [EXECUTE].

(f) Wait for the progam to load then press [REWIND].
When tape motion stops, remove and store the cartridge.

6.2 OPERATOR FUNCTIONS

6.2.1 Computer Control Keys

RUN	- Start execution of the program.
CONTINUE	- Used to enter input data requested by the program.
SPACE BAR	- Used during the profile to switch between MONITOR and RECORD modes.
f_6	- Used during the profile to trigger the printing of a full resolution parameter record in the summary report (This key is normally used to log water samples taken for system calibration purposes).
STOP	- Used at the end of the profile to end the nine-track data file, finish printing of the profile report, and end the program.
RESET	- Aborts the program. Use this key only if STOP key fails to perform its function. If used during profile data collection, follow the steps described under 6.5 ERROR RECOVERY.

6.2.2 Other Controls

(a) The sea probe may be turned on or off at any time during the profile with the front switches on the CTD control unit.

(b) The nine-track tape drive has several front controls which are normally required only to mount and dismount a tape. The tape drive CANNOT be taken offline at any time during a profile.

(c) The winch control is not handled by the CTD operator. Sea probe speed is controlled via voice communication with the winch operator.

6.2.3 Output to Operator

(a) The integral computer strip printer is used to print a record of the profile identification data after entry by the operator.

(b) The line printer outputs the profile summary report. The standard-depth and full resolution parameter records are both printed here during the profile.

(c) The computer display prompts the operator for input data, displays various program messages, and (during the profile) provides status information as illustrated in Figure 2.

(d) The computer beeper emits a single tone to signal a data error or some other condition requiring operator response. Table 1 is a list of the various error types which can cause a "beep" alarm during profiling.

(e) The CTD Control Unit displays full resolution values of temperature, conductivity ratio, and 'percent full-scale pressure' while the sea probe is switched on.

(f) Optionally, an analog plotter may be used to produce a graphical record of the profile; pressure-temperature and pressure-conductivity ratio plots are graphed on a single page. The ability to drive an analog plotter requires an optional D/A module installation for the CTD control unit.

(g) In the event of an abnormal condition, the Nine-track status and error display can be helpful in diagnosis. See 6.5 Error Recovery.

6.3 OPERATING PROCEDURES

Once the system has been installed as specified in Section 6.1 and the operator is acquainted with the system interfaces described in Section 6.2, the procedure descriptions of this section can more readily be understood.

The following set of procedures is performed sequentially for each profile:

(a) Start the program (perform system tests).

(b) Create a new data file.

(c) Enter profile identification data.

(d) Collect (and record) profile data.

Detailed descriptions of these procedures are given below.

6.3.1 Start the Program

Press the RUN key. The program first displays its name and version number and then conducts tests to verify that all required peripherals are properly connected to the computer. Also, any device capable of providing status information is polled to ensure that it can function as required.

If the program determines that all devices are functional, the message "All System Checks Okay" is momentarily displayed, the program continues to the next procedure, and no operator action is required. Otherwise, an appropriate failure message is displayed and program execution is suspended until the problem is corrected by the operator. Table 2 lists the possible messages,

causes, and corresponding corrective actions. When satisfied that the problem is rectified, press CONTINUE to re-execute the tests.

6.3.2 Create a New Data File

When the system tests have all been passed the progam creates a new data file on the nine-track unit to receive the data for this profile. Before this can be accomplished, the tape drive must be:

(a) ON LINE (switch selected).

(b) WRITE ENABLED (tape is fitted with a write ring).

(c) 1600 BPI mode (switch selected).

The program checks that these conditions are met. If not, an appropriate message is displayed and program execution is suspended. Correct the indicated condition and then press CONTINUE to re-execute the checks.

The actual file creation requires that the tape be positioned either immediately after the previous file(s) or at the start-of-tape if there are no other files. The tape is first reversed to the start of the previous file (or start-of-tape) and then forward-searched for the end-of-data mark. In most cases the mark is found and the new file is created. Thus, the program continues to the next procedure. However, if the end-of-data mark is not found within thirty seconds, a tape search time-out occurs.

When the tape has been searched for thirty seconds and end-of-data is not found, the following message is displayed: "Is this a NEW tape? [y/n]." Proceed as described in either: (a) empty tape; (b) non-empty tape; or (c) non-empty tape (trouble).

(a) There are no data previously recorded on this tape (this <u>is</u> a new tape). Press:

"y" CONTINUE

and the program will ask that you confirm this response:

Please confirm NEW tape [y/n]

<u>CAUTION</u>: If there are previously recorded data on the tape, and you respond "y" when asked to confirm, the old data will be destroyed.

- If you are sure there is no danger of data destruction, respond to the confirmation question with

"y" CONTINUE

The program will rewind to start-of-tape, create the new data file, and continue to the next procedure.

- If you wish to retract the "y" response made to the new tape question, respond to the confirmation question with:

"n" CONTINUE

The program will continue with a new search for end-of-data. The new search is also subject to a thirty second time-out.

(b) There are data previously recorded on this tape (This is not a new tape). Press

"n" CONTINUE

The program will continue with a new search for end-of-data which is also subject to a thirty second timeout. In the event of repeated file search time-outs, consult (c) below.

(c) There are data previously recorded on this tape, but after several time-outs it appears that end-of-data cannot be found. Press

RESET

This aborts program execution and ends the file search. Rewind and dismount the data tape. Mount a new tape and restart the program.

6.3.3 Enter Profile Identification Data

Once an output data file has been successfully created, the profile identification is collected in this procedure. The operator is asked to provide fourteen data items which are later recorded in the header of the data file. The program prompts for each item with a display formatted as:

item name? [current value]

The name and valid range for each item are listed in Table 3.

Use the numeric keys followed by CONTINUE to enter each value. The displayed "current value" for an item may be selected by simply pressing CONTINUE. Only values within the item's valid range will be accepted. Once a value has been entered for each of the items, a printed list is generated on the strip printer and the message "Please verify header data [y/n]" is displayed. If any changes are required, respond with "n" and then change any or all items when prompted (to leave an item unchanged, simply respond to its prompt with CONTINUE). When no further changes are required, answer "y" to verify and record the Profile Identification Data and continue to the next procedure.

6.3.4 Collect Profile Data

Once the data file header has been recorded, the actual profile data acquisition and logging is performed by this procedure.

If a calibration water sample is required during this profile, ensure that the Rosette sampler is loaded and ready to trigger on command.

Turn on the sea probe

The CTD displays should indicate ambient temperature and about 0% pressure. The conductivity display may be erratic while the probe is out of the water.

The status record should show MONITOR mode, depth of about 0 m., and sample number increasing at a rate of 4 per second. There may be Rate error alarms (caused by the erratic conductivity channel) until the probe is in the water.

Stabilize the Sensors

Lower the probe into the water until the sensors are fully immersed, stop, and wait for the sensor readings to stabilize. At this point there should be no alarms, stable CTD displays and data sampling at 4 per second.

Log the Data

Press the space bar to switch to RECORD mode. There should be tape motion about once every 4 seconds. Lower the probe through the water column, slowly increasing the probe speed, until optimal speed is attained.

The operator's function now is to maintain optimal rate of descent for the sea probe throughout the period of profiling. This rate is dependent on two factors:

(a) Time available: Slower probe speed results in more data per unit of water and generally, maximum data yields maximum information (therefore, the slower the better). However, there is a practical limit on how much time can be spent for each profile.

(b) Water structure: As the probe moves from one type of water to another (for example, the temperature decreases abruptly), it takes time for the sensors to "catch-up" and accurately report the new readings. Therefore, a more variable water column requires slower probe speed to return a comparable level of information.

While the program is in RECORD mode, a line of summary report data is printed as the probe reaches each of the standard depths. The operator should

monitor this calculated information. It is indicative of water structure and can be helpful in maintaining optimal probe speed.

6.4 DATA QUALITY ASSESSMENT

The final section of the Profile Summary Report (Post-profile status) is printed immediately after the profile data logging is completed. It provides the operator with an immediate assessment of the data quality.

First, check the program performance parameter "Samples Blocked". It is roughly proportional to the amount of input data which the computer was unable to accept. If the value of this parameter is higher than 0.1% of total input data. program performance should be improved by reconfiguration (consult Section 5).

Throughout the data collection period (while the program is in either MONITOR or RECORD mode), a portion of the Mark IV data (nominally 16%) is sampled and analyzed for error content. This process divides the data sample into six categories: Sync, Vref, PRate, TRate, CRate, and valid data. The "Error Summary" lists the quantities of data in each of the five error categories. These results are given both as absolute quantities and as percentages of the data sample. Normally the error categories should account for less than 1% of the sample.

6.5 ERROR RECOVERY

6.5.1 RESET Key

Use of the RESET key causes the computer to immediately revert to its power-up state. This capability is provided to enable the operator to regain control of the machine in the event of software failure.

Immediately after use of the key, the operator must check the status of the nine-track data file as follows:

(a) If the data file header has not yet been recorded (i.e. program did not start the "Collect Profile Data" procedure), the data file status is okay. No further action is necessary.

(b) If the data file header has been recorded, the operator must manually write an end-of-data mark with the following keystrokes.

cmd 708,"WEWE" [EXECUTE]

6.5.2 HPL System Error

When a software system error occurs, the computer beeps and displays an error number which references a description that helps pinpoint the cause of the error. A complete list of error codes is contained in the HP9825 Operating and Programming Manual.

The program is protected, whenever possible, from termination due to an HPL system error. If an error occurs during the input of operator-supplied data, simply re-enter the data correctly and the program will continue. However, if a system error occurs at any other time, the program should be reloaded (Section 6.1.5) and restarted (Section 6.3.1). Note that if an error occurs while the data output file is active, the progam will automatically write the necessary end-of-data mark.

If status bit 7 (ERROR) of the tape drive's status and error display is on, some unusual condition occurred during the profile. In almost every case, the unusual condition is an uncorrectable write error. The tape may be unusable or the tape head may require cleaning. Refer to the Operations and Maintenance manual for the tape drive. The tape drive checks all data as it is written on tape, using a second magnetic head to read it back. Dust or stray magnetic oxide particles may occasionally cause a bad spot on the tape. If this should occur, the tape drive automatically backs up, erases the faultly block and re-records it, leaving a gap at the bad spot. This process is repeated if necessary. If the write data and read data still do not match after two rewrites an uncorrectable write error is registered by the tape controller.

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Table 1. Causes of alarm conditions.

Alarm	Condition(s)	Possible Cause(s)
SYNC	1) Data transmission loss between sea probe and CTD control unit.	- water in sea cable connector - damaged sea cable - damaged sea probe - damaged deck cable - bad grounding at winch - faulty CTD control unit
	2) Data transmission error between CTD control unit and computer (16 bit interface).	- faulty interface connectors - faulty CTD control unit - faulty interface
VREF error	1) Power regulator in sea probe is operating outside limits.	- damaged sea probe
	2) Data transmission error between sea probe and computer (16 bit interface).	- see causes for SYNC error
RATE	1) The rate of change of one or more of the measured paramters has exceeded its pre-set limit.	- excessive speed of sea probe through a varying water mass. - water in sensor connector - faulty sensor - incorrect settings of the rate limits[a]
	2) Data transmission error between sea probe and computer (16 bit interface).	- see causes for SYNC error
Other error alarm	1) An unrecognized control command received from computer keyboad	- key jammed
	2) Computer is unable to attain full-rate logging of the input data.	- f_6 key used more frequently than once per second - key jammed - depth trigger table is improperly set up[a]

[a]See Section 5 Program Configuration.

Table 2. System test failures.

Message	Cause(s)	Action(s)
Check printer and interface	- printer is off-line	
	- interface cable is disconnected	
	- printer is out of paper	
	- interface software failure	- press RESET and restart program
	- wrong select code	- ensure select code=6
	- hardware problem	- repair or replace interface or printer
Check 16 bit interface	- interface software failure	- press RESET and restart program
	- wrong select code	- ensure select code=2
	- hardware problem	- ensure correct jumpers installed in interface
		- repair or replace interface
Check HPIB interface	- interface software failure or unknown bus state	- press RESET and restart program
		- disconnect all bus devices
	- wrong select code	- ensure select code=7
	- hardware problem	- ensure correct jumpers installed in interface
		- repair or replace interface
Check internal printer	- internal printer is out of paper	
Check 9 track recorder	- not connected to interface	
	- wrong bus addresses	- ensure addresses set to 08, 09
	- incompatible device	- use specified model
	- hardware problem	- repair or replace

Table 3. Data items for profile identification.

Item name	Valid range	Entry format
Ship #	1..99	
Trip #	1..999	
Station #	1..999	
Profile #	1..999	
Degrees of N Latitude	0..89	
Minutes of N Latitude	0.0..59.9	
Degrees of W Longitude	0..99	
Minutes of W Longitude	0.0..59.9	
Sounder depth	9..9999	(metres)
Date (GMT)	yy = 83..99 mm = 01..12 dd = 01..31	yymmdd
Time (GMT)	hh = 0..23 mm = 00..59	hhmm

Table 4. Comparison of pressure to depth at various latitudes, pressures and mean densities.

LAT	PRES	GRAVITY	Mean "in situ" density (kg/m^3)				
			1015	1020	1025	1030	1035
deg	dbar	m/sec^2	Depth				
0.0	500.0	9.780875	503.65	501.18	498.73	496.31	493.91
0.0	1000.0	9.781431	1007.24	1002.30	997.41	992.57	987.77
10.0	500.0	9.782431	503.57	501.10	498.65	496.23	493.84
10.0	1000.0	9.782988	1007.08	1002.14	997.25	992.41	987.62
20.0	500.0	9.786917	503.34	500.87	498.43	496.01	493.61
20.0	1000.0	9.787474	1006.61	1001.68	996.79	991.96	987.16
30.0	500.0	9.793796	502.98	500.52	498.08	495.66	493.26
30.0	1000.0	9.794353	1005.91	1000.98	996.09	991.26	986.47
40.0	500.0	9.802245	502.55	500.09	497.65	495.23	492.84
40.0	1000.0	9.802802	1005.04	1000.11	995.24	990.40	985.62
50.0	500.0	9.811251	502.09	499.63	497.19	494.78	492.39
50.0	1000.0	9.811807	1004.12	999.20	994.32	989.50	984.72
60.0	500.0	9.819726	501.65	499.20	496.76	494.35	491.96
60.0	1000.0	9.820282	1003.25	998.33	993.46	988.64	983.87
70.0	500.0	9.826643	501.30	498.84	496.41	494.00	491.61
70.0	1000.0	9.827200	1002.55	997.63	992.76	987.95	983.17
80.0	500.0	9.831163	501.07	498.61	496.18	493.77	491.39
80.0	1000.0	9.831720	1002.08	997.17	992.31	987.49	982.72
90.0	500.0	9.832734	500.99	498.53	496.10	493.69	491.31
90.0	1000.0	9.333290	1001.92	997.01	992.15	987.33	982.56

APPENDIX 1: SYSTEM COMPONENTS

System Hardware Components

Manufacturer	Item	Component(s)
General Oceanics Inc. 5535 N.W. 7th Ave. Miami, Florida 33127 (305) 621-2882	- Model 1015 Rosette multi-bottle array system	- Rosette sampler - Rosette control unit
Guildline Instruments Ltd. 21 Gilroy St. Smith Falls, Ont. K7A 4S9 (613) 283-3000	- Model N8707 vertical profile system	- Sea probe and sensors - CTD control unit - Variosens interface
Interocean Systems Inc. 3540 Aero Ct. San Diego, CA 92123 (714) 565-8400	- Model 522R Analog signal conditioner and four channel recorder	- signal conditioner - XXY plotter
Hewlett-Packard (Canada) Ltd. 6877 Goreway Drive Mississauga, Ont. L4V 1M8 (416) 678-9430	- HP 9825 computer system (See Appendix 2)	- computer - line printer - digital tape recorder
Hammond Manufacturing Co. Guelph, Ont.	- CAT #1584H88 (or equivalent)	- A.C. power bar. (15A, 125V)

APPENDIX 2: HP 9825 COMPUTER SYSTEM

Hewlett-Packard 9825 Computer System

HP Hardware

- 9825B Computer (with 62 K bytes read/write memory)
- 98032A Parallel I/O interface
- 98034A HP-IB interface
- 98032A (Option 066) Printer interface
- 9866B Line Printer

HP Software

Standard HPL programming language ROMs, including:

- String Variables Programming
- Advanced Programming
- Systems Programming
- General I/O Programming
- Extended I/O Programming

Other Hardware

- Series GPIB-1050 Nine-track tape drive with 32 K buffer memory (Includes tape transport, data formatter, and bus interface unit)

  Innovative Data Technology
  4050 Morena Boulevard
  San Diego, CA 92117
  (714) 270-3990

APPENDIX 3: DATA FILE HEADER FORMAT

Field[1] Name	Field Width	First Byte	Last Byte	FORTRAN Read Format	Note
Ship No.	2	1	2	I2	
Trip No.	3	3	5	I3	
Station No.	3	6	8	I3	
Latitude (N)	5	9	13	I5	2
Longitude (W)	5	14	18	I5	2
Year	2	19	20	I2	
Month	2	21	22	I2	
Day	2	23	24	I2	
Hour	2	25	26	I2	
Minute	2	27	28	I2	
Sounder Depth	5	29	33	F5.1	
File Type	5	34	38	A5	3
Profile No.	3	39	41	I3	

Notes

1. All fields are left-padded, if necessary, with the ASCII space character (decimal 32).

2. Latitude and Longitude are encoded as INT (degrees)* 1000 + INT (minutes* 10). Resolution is tenths of a minute.

3. All files produced by CTD LOGGER are type "ΔBCTD," where Δ represents the ASCII space character.

4. The block (physical record) containing the 41 byte header is padded with ASCII line feed characters (decimal 10).

APPENDIX 4: SAMPLE PROFILE SUMMARY REPORT

Ship#10 Trip# 15
Station# 35
CTD Profile# 35

Lat: 44 40.0 N
Long: 50 30.0 W

1984 07 15
16:30 GMT

Sounding: 53m.

CALIBRATION DATA

Probe ID	FS pressure	P offset	T offset	C scaling
(DEFAULT)	100 bar	0.00 bar	0.000 degC	1.000000

	Depth	Temp	Salinity	Sigma-t	Cond Ratio	
	0.8	14.91	32.279	23.894		
	1.1	14.93	32.277	23.891		
	3.2	14.92	32.280	23.894		
	5.1	14.87	32.285	23.912		
	7.6	14.76	32.261	23.912		
	10.2	14.12	32.289	24.069		
	13.2	13.49	32.533	24.385		
	16.7	11.92	32.308	24.515		
	20.1	9.58	32.265	24.885		
	25.3	9.31	32.240	24.909		
	30.3	8.62	32.189	24.975		
	35.3	5.90	32.170	25.329		
	40.0	5.25	32.336	25.536		
	50.1	5.21	32.344	25.546		
*	50.75	5.2108	32.34733	25.54941	0.73073	(uncorrected)
*	50.58	5.2110	32.34473	25.54732	0.73068	(uncorrected)
*	50.33	5.2110	32.34730	25.54936	0.73073	(uncorrected)
*	50.15	5.2108	32.35130	25.55256	0.73080	(uncorrected)
*	50.30	5.2110	32.34670	25.54889	0.73071	(uncorrected)
*	50.83	5.2105	32.34754	25.54960	0.73073	(uncorrected)
*	50.63	5.2110	32.33858	25.54245	0.73055	(uncorrected)
*	50.45	5.2105	32.34772	25.54975	0.73073	(uncorrected)
*	50.55	5.2110	32.34658	25.54879	0.73071	(uncorrected)
*	50.88	5.2113	32.34679	25.54892	0.73073	(uncorrected)
*	50.78	5.2113	32.34561	25.54799	0.73070	(uncorrected)
*	50.58	5.2098	32.35084	25.55230	0.73078	(uncorrected)

690400 Bytes Input
96800 Bytes Recorded

3452 Points Sampled (16.0% of Input)
0 Samples Blocked

ERROR SUMMARY

	Sync	Vref	P_Rate	T_Rate	C_Rate
AS COUNTS:	0	0	0	0	0
AS %SAMPLE:	0.0	0.0	0.0	0.0	0.0

APPENDIX 5: MODIFIED RECOMBINATION METHOD

Guildline Recombination Method (used by CTD Logger)

```
If bit (11,offset) THEN
    A: = 1024 * Suppression + (Offset - 2048) + 2**21
Else
    A: = 1024 * Suppression + Offset + (1023 * 2048)
If A > = 2**22 THEN
    A: = A - 2**22      [clear carry]
If A > = 2**21 THEN
    A: = A - (2**22 - 1)      [invert if negative]
```

Recommended New Method

```
A: = 1024 * Suppression + Offset -  2099200
```

Justification

The Guildline method is a translation of the hardware implementation used in the deck unit electronics. A different approach proves more efficient in software.

Background

The A/D converter used in the sea probe is a 12 bit device (4096 levels of digitization). The 12-bit data transmitted from the probe is coded in "offset binary" (not two's complement).

Thus, the following scale applies:

data value	measurement
0	- 2048
1	- 2047
.	.
.	.
2048	0
.	.
.	.
4095	+ 2047

[i.e. measurement = data - 2048]

Although the suppression register is not digitized by the same A/D device as everything else, it is encoded by the same scheme. Therefore we should convert both suppression and offset from their "offset binary" form before going any further into the generation of a real number. Having accomplished this, the two components may be mathematically combined taking into consideration the different weighting of each (Suppression is shifted left 10 bits, i.e. multiplied by 1024).

1024 * (Suppression data - 2048) + (Offset data - 2048)

or 1024 * Suppression data + Offset - 2099200

To illustrate, consider the data used by Guildline to demonstrate its technique:

		TRANSMITTED	MEASURED
1)	P_{supr}	1 0 0 0 0 0 0 0 0 0 0 1 801_h 2049	1
	P_{off}	0 0 1 1 0 1 1 0 0 1 0 1 365_h 869	- 1179

P_{data} = (1024 * 2049) + 869 - 2099200 = - 155

P = - 155/400 = - 0.3875 % full scale

(Note the absence of the single-bit error encountered by Guildline)

		TRANSMITTED			MEASURED
2)	T_{supr}	1 0 0 0 0 1 0 0 0 1 0 0	844_h	2116	68
	T_{off}	0 1 0 1 0 1 1 0 1 1 0 1	$56D_h$	1389	- 659

T_{data} = (1024 * 2116) + 1389 - 2099200 = 68973

T = 68973/4000 = 17.24325 °C

		TRANSMITTED			MEASURED
3)	C_{supr}	1 0 0 0 0 1 0 1 0 0 0 0	850_h	2128	80
	C_{off}	1 0 1 0 1 0 1 1 1 1 1 1	ABF_h	2751	703

C_{data} = (1024 * 2128) + 2751 - 2099200 = 82623

C = 82623/160000 = 0.51639375

Useful Relationships

1)	Scaling	P	400
		T	4000
		C	160,000
2)	Numerical resolution	P	0.0025 %FS
		T	0.00025 °C
		C	0.00000625
3)	Suppression resolution	P	2.56 % FS
		T	0.256 °C
		C	0.0064

4) Approximate tracking (Based on 100 Hz clocking of supression reg.)

P 10.24 %FS/sec (51.2 m/sec or 102.4 m/sec)

T 1.024 °C/sec

C 0.0256 unit/sec

5) Sensor-imposed upper limits

				Suppression															
(P)	150%	60,000	EA60	0	0	1	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0
(T)	+40°C	160,000	2F100	1	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0
(C)	1.6	256,000	3E800	1	1	1	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0

P_s (max) $\approx 40_{hex}$ $\qquad$ P_{so} (max) $\approx 840_h$

T_s (max) $\approx 90_{hex}$ in offset binary → T_{so} (max) $\approx 890_h$

C_s (max) $\approx FF_{hex}$ $\qquad$ C_{so} (max) $\approx 900_h$

6) Sensor-imposed minima

(T) - 2 - 8000 3FE0C0 → T_s(min) $\approx$ - 3 ; T_{so}(min) $\approx 7FO_h$

(P,C) 0 0 0 → X_s(min) $\approx$ 0 ; X_{so}(min) $\approx 800_h$

Further Comparative Test Data

Temperature = - 2°C

Suppression data = 2041_{10} in offset binary

Offset data = 1216_{10}

Guildline result = - 1.99975 °C (single bit error)

Method result = - 2.0000 °C

Temperature = -2°C

Suppression data = 2040_{10} in offset binary

Offset data = 2240_{10}

Guildline result = - 1.99975 °C (single bit error)

Method result = - 2.000 °C

Conductivity = 0

Suppression data = 2048 in offset binary

Offset data = 2048

Guildline result = 0.000000

Method result = 0.000000

Conductivity = 1.6

Suppression data = 2298 in offset binary

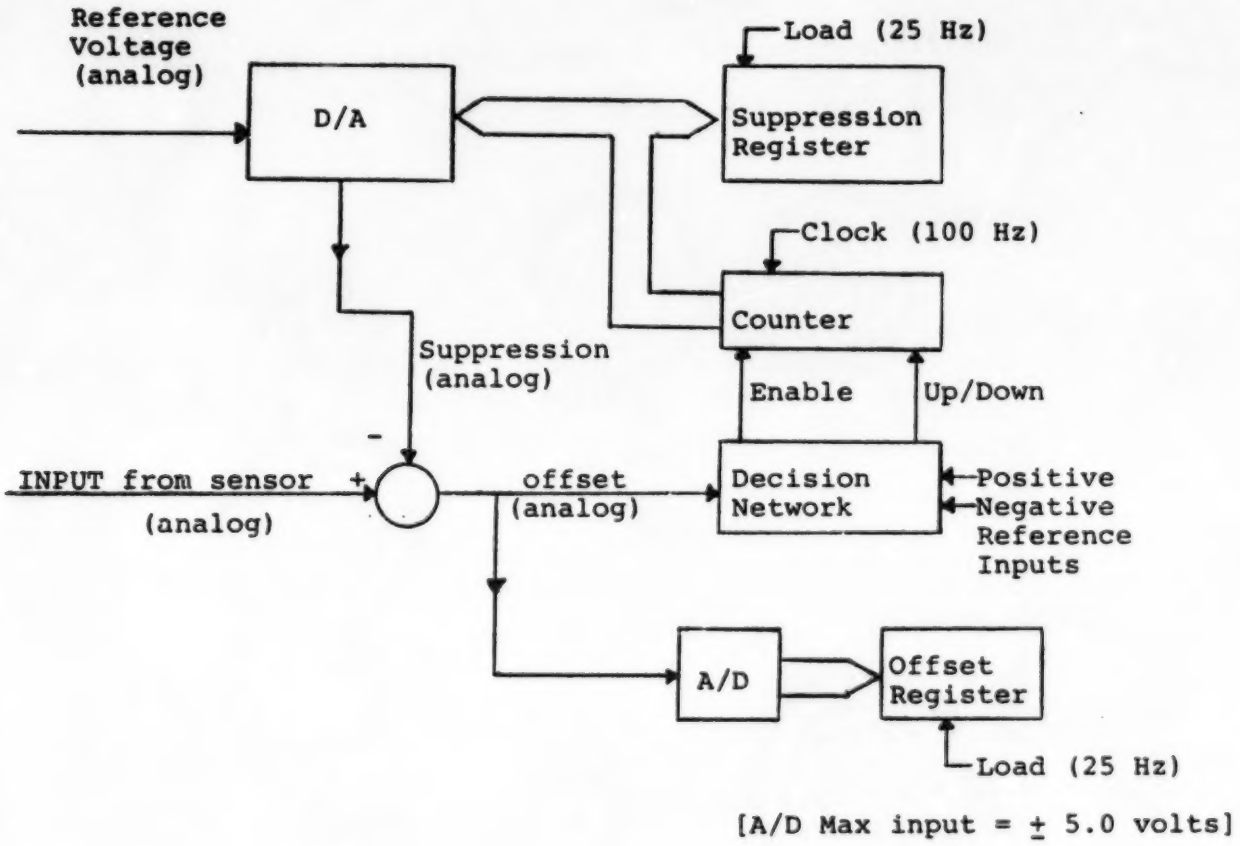
Offset data = 2048

Guildline result = 1.600000

Method result = 1.600000

GUILDLINE'S

HARDWARE GENERATION OF SUPPRESSION & OFFSET



Decision Network

If analog offset is within limits (+ & - references) counter is not enabled

Else counter is enabled and will count up or down (as appropriate) at 100 Hz

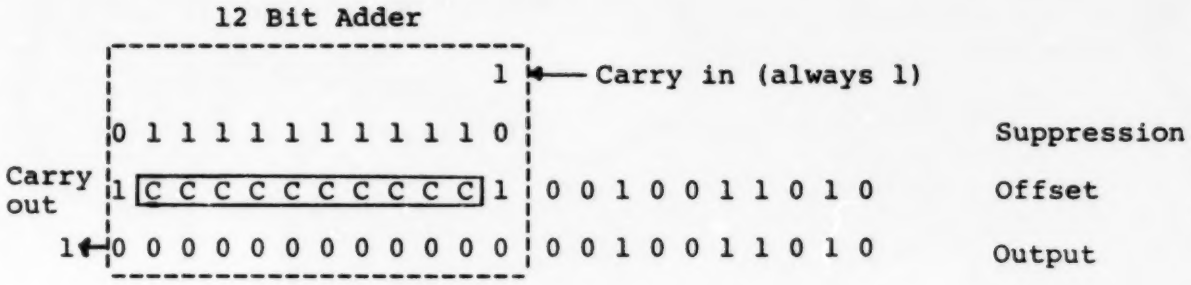
Tracking

Three or four A/D cycles per read of registers (registers are read at 25 Hz).

HARDWARE IMPLEMENTATION
OF GUILDLINE RECOMBINATION

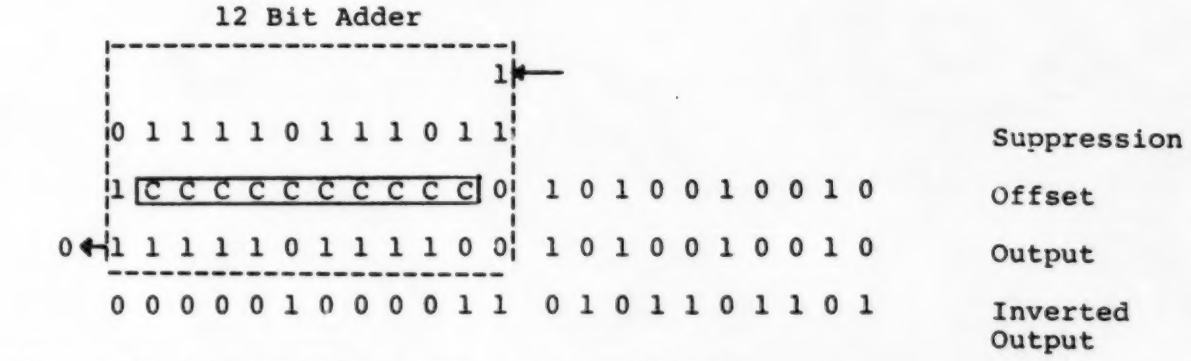
(Inverted Data Input)

(P)


12 Bit Adder
1
Carry in (always 1)
0 1 1 1 1 1 1 1 1 1 1 0
Suppression
Carry out
1 C C C C C C C C C C C 1
0 0 1 0 0 1 1 0 1 0
Offset
1
0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 0 0 1 1 0 1 0
Output

Sign = 1, number is negative = - 154

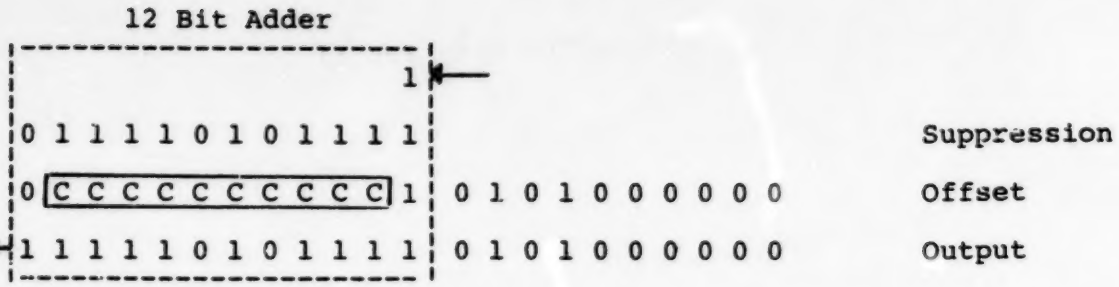
(T)



Sign = 0, invert bits, number is positive

= + 68973

(C)



Sign = 0, invert bits, number is positive

0 0 0 0 0 1 0 1 0 0 0 0 1 0 1 0 1 1 1 1 1 1 — Inverted Output

= + 82623

NOTES

1) Bit 11 of offset is added with bit 11 of suppression

2) The constant marked in (C C C ....) is either 10 zeroes [if bit 11 of offset] or 10 ones [if not bit 11 of offset]

3) The carry input is always one

4) The carry output is used as a sign indicator (+ or -) and a control to invert the data bits (all 22 bits)

5) Input data ~~are~~ are inverted.

APPENDIX 6: CONSTANTS USED IN THE CALCULATION OF PRACTICAL SALINITY

$a_0 = 0.0080$

$a_1 = -0.1692$

$a_2 = 25.3851$

$a_3 = 14.0941$

$a_4 = -7.0261$

$a_5 = 2.7081$

$b_0 = 0.0005$

$b_1 = -0.0056$

$b_2 = -0.0066$

$b_3 = -0.0375$

$b_4 = 0.0636$

$b_5 = -0.0144$

$c_0 = 0.676\ 609\ 7$

$c_1 = 2.005\ 64 \times 10^{-2}$

$c_2 = 1.104\ 259 \times 10^{-4}$

$c_3 = -6.9698 \times 10^{-7}$

$c_4 = 1.0031 \times 10^{-9}$

$d_1 = 3.426 \times 10^{-2}$

$d_2 = 4.464 \times 10^{-4}$

$d_3 = 4.215 \times 10^{-1}$

$d_4 = -3.107 \times 10^{-3}$

$e_1 = 2.070 \times 10^{-4}$

$e_2 = -6.370 \times 10^{-8}$

$e_3 = 3.989 \times 10^{-12}$

$k = 0.0162$

APPENDIX 7: CONSTANTS USED IN THE CALCULATION OF SIGMA-t

$a_0 = 999.942\ 594$

$a_1 = 6.793\ 952 \times 10^{-2}$

$a_2 = -9.095\ 290 \times 10^{-3}$

$a_3 = 1.001\ 685 \times 10^{-4}$

$a_4 = -1.120\ 083 \times 10^{-6}$

$a_5 = 6.536\ 332 \times 10^{-9}$

$b_0 = 8.244\ 93 \times 10\text{-}1$

$b_1 = -4.0899 \times 10^{-3}$

$b_2 = 7.6438 \times 10^{-5}$

$b_3 = -8.2467 \times 10^{-7}$

$b_4 = 5.3875 \times 10^{-9}$

$c_0 = -5.724\ 66 \times 10^{-3}$

$c_1 = 1.0227 \times 10^{-4}$

$c_2 = -1.6546 \times 10^{-6}$

$d_0 = 4.8314 \times 10^{-4}$

APPENDIX 8: PROGRAM LISTING

```
0: % "CTD LOGGER Ver 3.00"
1:
2: wrt 0," CTD LOGGER";wait 2000
3: wrt 0,"Version: 3.00";wait 2000
4:
5: lkd ;mdec
6: cll 'ALLOCATE'
7: cll 'CHECK CONFIGURATION'
8: dsp "All System Checks Okay";wait 1000
9: cll 'START FILE'
10: cll 'MONITOR/RECORD CTD'
11: cll 'END FILE'
12: end
13:
14:
15: "ALLOCATE":
16: dim Y$[20],W$[2,7],D$[1],G$[1]
17: dim N[0:3],Z[0:15]
18: dim C[3],F[7],F$[9]
19: dim A[14]
20: dim G[0:5],H[0:5],I[0:4],J[4],K[3]
21: dim P[0:5],Q[0:4],R[0:2]
22: dim A$[800+16],B$[800+16]
23: dim I$[64+16],J$[64+16],K$[64+16],L$[64+16]
24: dev "IO16",2
25: dev "HPIB",7
26: dev "9Tc",708
27: dev "9Td",709
28: buf "header",100,3
29: buf "A",A$,4;buf "B",B$,4
30: buf "1",I$,2;buf "2",J$,2;buf "3",K$,2;buf "4",L$,2
31: ret
32:
33: "CHECK CONFIGURATION":
34: time 5
35: on err "HPIBerr"
36: cli "HPIB";rds("HPIB",p1,p2,p3)}p4
37: if p1#0 or p2#213 or p3#64 or p4#76;gto "HPIBerr"
38: wait 5
39: on err "IO16err"
40: if rds("IO16")#288;gto "IO16err"
41: wait 5
42: on err "PRNTerr"
43: if rds(6)#288;gto "PRNTerr"
44: fmt 3x;wrt 6
45: wait 5
46: on err "DISPerr"
47: if not bit("1000",rds(16));gto "DISPerr"
48: fmt 3x;wrt 0;wrt 16;rds(16)}p1;if not bit("1100",p1);gto "DISPerr"
49: wait 5
50: on err "9TTerr"
51: clr "9Tc";rdb("9Tc")}p1;rdb("9Tc")}p1
52: if bit("11xx",p1) or bit("1x1xx",p1);gto "9TTerr"
53: if band(192,p1)#0;gto "9TTerr"
54: wait 5
55: time 0;on err "HPLerr"
56: ret
```

```
57: "HPIBerr":ent "Check HPIB Interface",p1:gto "CHECK CONFIGURATION"
58: "IO16err":ent "Check 16 Bit Interface",p1;gto "CHECK CONFIGURATION"
59: "PRNTerr":ent "Check Printer & Interface",p1;gto "CHECK CONFIGURATION"
60: "DISPerr":ent "Check Internal Printer",p1;gto "CHECK CONFIGURATION"
61: "9TTerr":ent "Check 9-Track Recorder",p1;gto "CHECK CONFIGURATION"
62: "HPLerr":jmp erl-cln
63:
64:
65: "START FILE":
66: cll 'SETUP TAPE DRIVE'
67: "change":cll 'CHANGE H DATA'
68: cll 'PRINT H DATA'(16);% " 16 is internal printer"
69: ""}Y$;ent "Please verify header data [y/n]",Y$
70: Y$[1,1]}Y$;if Y$#"y" and Y$#"n";beep;gto -1
71: if Y$="n";fmt 3x,"CANCELLED",/,16"-",3/;wrt 16;gto "change"
72: fmt 4x,"VERIFIED",/,16"-",3/;wrt 16
73: cll 'FILL HEADER BUFFER'
74: tfr "header","9Td"
75: on err "ERROR"
76: cmd "9Tc","PB"
77: ret
78:
79:
80: "MONITOR/RECORD CTD":
81: cll 'INITIALIZE'
82: "rm":sfg 0
83: if flg9;oni "IO16","Dend";on key "Kend";ret
84: if flg0;gto -1
85: for B=49 to 52;char(B)}G$;gsb "GT"
86: wrt .1,W$[1+flg1],D,R,Q,U+V+W,0
87: if flg1 and D>rM;M+1}M;gsb "PA"
88: if flg2;cfg 2;gsb "PD"
89: next B;gto "rm"
90:
91: "END FILE":
92: cmd "9Tc","WE WE";dsp " "
93: on err "HPLerr"
94: fmt /,f.0," Bytes Input";wrt 6,F
95: if F=0;gto +14
96: fmt f.0," Bytes Recorded";wrt 6,G
97: fmt /,f.0," Points Sampled (",f.1,"% of Input)"
98: wrt 6,0,3200*0/F
99: fmt f.0," Samples Blocked";wrt 6,H
100: fmt /,16x,"ERROR SUMMARY",/
101: wrt 6
102: fmt 10x,"  Sync  Vref  P_Rate  T_Rate  C_Rate"
103: wrt 6
104: fmt 10x,36"-";wrt 6
105: fmt "AS COUNTS:",f5.0,x,f5.0,2x,f5.0,3x,f5.0,3x,f5.0
106: wrt 6,R,Q,U,V,W
107: fmt "AS %SAMPLE:",f5.1,x,f5.1,2x,f5.1,3x,f5.1,3x,f5.1
108: wrt 6,100R/0,100Q/0,100U/0,100V/0,100W/0
109: fmt 2/;wrt 6
110: dsp "RESET then RUN to start LOGGER"
111: ret
112:
113:
114: % "       ************** PROCESS DMA INTERRUPT ************"
115: "D":tfr "IO16",D$,400
116: B00+F}F
```

```
117: if D$="A";"B"}D$;gto "Db"
118: "A"}D$;gto "Da"
119:
120: "Da":if flg1;800+G}G;wrt "9Td.5",A$[1,800]
121: if not flg0;H+4}H;gto +5
122: cfg 0;buf "1";wrt "1.9";A$[1,64]}I$[1,64]
123: buf "2";wrt "2.9";A$[201,264]}J$[1,64]
124: buf "3";wrt "3.9";A$[401,464]}K$[1,64]
125: buf "4";wrt "4.9";A$[601,664]}L$[1,64]
126: buf "A";iret
127:
128: "Db":if flg1;800+G}G;wrt "9Td.5",B$[1,800]
129: if not flg0;H+4}H;gto +5
130: cfg 0;buf "1";wrt "1.9";B$[1,64]}I$[1,64]
131: buf "2";wrt "2.9";B$[201,264]}J$[1,64]
132: buf "3";wrt "3.9";B$[401,464]}K$[1,64]
133: buf "4";wrt "4.9";B$[601,664]}L$[1,64]
134: buf "B";iret
135:
136: "Dend":iret
137: % "       ****************************************************"
138:
139:
140: "ERROR":if rom#69 or ern#5;gto +2
141: on err "ERROR";ret
142: oni "IO16","Dend";on key "K"
143: fmt /,5x,"FATAL PROGRAM ERROR:",c1,f.0," in line ",f.0,/
144: wrt 6,char(rom),ern,erl
145: cll 'END FILE';end
146:
147:
148:
149: % "       ************ PROCESS OPERATOR INTERRUPT *********"
150:
151: "K":key}K
152: if K=32;cmf 1;gto "Kout"
153: if K=71;sfg 2;gto "Kout"
154: if K=1;sfg 9;gto "Kout"
155: beep;dsp "  ?????"
156: "Kout":on key "K";kret
157:
158: "Kend":on key "Kend";kret
159: % "       ****************************************************"
160:
161:
162: "GT":gsb "LD"
163: 0+1}0;if Z[0]#0;beep;R+1}R;ret
164: if band(960,Z[1])#576;beep;Q+1}Q;ret
165: gsb "CO"
166: if C<.5;gto +4
167: if abs(C[1]-P)>50;U+1}U;beep;ret
168: if abs(C[2]-T)>15;V+1}V;beep;ret
169: if abs(C[3]-C)>.5;W+1}W;beep;ret
170: 10(C[1]}P)}D;C[2]}T;C[3]}C
171: ret
172:
173:
174: "LD":1}Z[0]
175: jmp band(-4096,rdb(B$))=-4096
176: band(4095,cmprdb(B$))}Z[1]
```

```
177: band(4095,cmprdb(G$))}Z[2]
178: band(4095,cmprdb(G$))}Z[3]
179: band(4095,cmprdb(G$))}Z[4]
180: band(4095,cmprdb(G$))}Z[5]
181: band(4095,cmprdb(G$))}Z[6]
182: band(4095,cmprdb(G$))}Z[7]
183: band(4095,cmprdb(G$))}Z[8]
184: band(4095,cmprdb(G$))}Z[9]
185: band(4095,cmprdb(G$))}Z[10]
186: band(4095,cmprdb(G$))}Z[11]
187: band(4095,cmprdb(G$))}Z[12]
188: band(4095,cmprdb(G$))}Z[13]
189: band(4095,cmprdb(G$))}Z[14]
190: cmprdb(G$))A;band(4095,A)}Z[15]
191: if band(-4096,A)=-4096;0}Z[0]
192: ret
193:
194:
195: "CO":1024Z[2]+band(2047,Z[3])+N[bit(11,Z[3])]}A
196: if A>=N[2];A-N[2]}A
197: if A>=N[1];A-N[3]}A
198: A*F[1]+F[4]}C[1]
199: 1024Z[4]+band(2047,Z[5])+N[bit(11,Z[5])]}A
200: if A>=N[2];A-N[2]}A
201: if A>=N[1];A-N[3]}A
202: A*F[2]+F[5]}C[2]
203: 1024Z[6]+band(2047,Z[7])+N[bit(11,Z[7])]}A
204: if A>=N[2];A-N[2]}A
205: if A>=N[1];A-N[3]}A
206: A*F[3]}C[3]
207: ret
208:
209:
210: "PA":gsb "SE"
211: wrt 6.2,D,T,S,E;ret
212:
213: "PD":P-F[4]}P;T-F[5]}T;C/F[6]}C;gsb "SE"
214: wrt 6.3,D,T,S,E,C
215: P+F[4]}P;T+F[5]}T;C*F[6]}C;ret
216:
217:
218: "SE":1+T(J[1]+TJ[2])+C(J[3]+TJ[4]))I
219: P(K[1]+P(K[2]+PK[3]))/I+1)I;% " Rp"
220: I[0]+T(I[1]+T(I[2]+T(I[3]+TI[4])))}J;% " rt"
221: \(C/JI)}I;% "  \Rt"
222: H[0]+I(H[1]+I(H[2]+I(H[3]+I(H[4]+IH[5])))))J
223: J(T-15)/(1+.0162(T-15)))J;% "  deltaS"
224: J+G[0]+I(G[1]+I(G[2]+I(G[3]+I(G[4]+IG[5])))))S
225: P[0]+T(P[1]+T(P[2]+T(P[3]+T(P[4]+TP[5])))))I
226: Q[0]+T(Q[1]+T(Q[2]+T(Q[3]+TQ[4])))}J
227: R[0]+T(R[1]+TR[2])}A
228: I+S(J+A\S+4.8314e-4S)-1000}E
229: ret
230: % "*************************************************************************"
231:
232: "INITIALIZE":
233: buf "A";buf "B"
234: buf "1";buf "2";buf "3";buf "4"
235: 0}A}B}C}D}E}F}G}H}I}J}K}M}N}O}P}Q}R}S}T}U}V}W
236: cll 'SET CO CONSTANTS'
```

```
237: cll 'SET SE CONSTANTS'
238: cll 'SET PROFILE TRIGGERS'
239: cll 'INITIALIZE CONTROL'
240: cll 'PRINT PROFILE ID'
241: fmt 1,c7,x,f.0,"m S=",f.0," V=",f.0," R=",f.0,x,f.0
242: fmt 2," ",f6.1,3x,f5.2,3x,f6.3,4x,f6.3
243: fmt 3,"*",f7.2,2x,f7.4,x,f8.5,2x,f8.5,2x,f7.5," (uncorrected)"
244: fmt 5,z,c800
245: fmt 9,z,32x
246: cll 'START DMA'
247: dsp "Waiting for CTD data"
248: ret
249:
250: "INITIALIZE CONTROL":
251: cfg 0,1,2,9;sfg 14;"Monitor")W$[1];"Record ")W$[2]
252: time 0
253: oni "IO16","D"
254: on err "ERROR"
255: on key "K"
256: ret
257:
258: "START DMA":
259: buf "A";buf "B"
260: "B")D$;tfr "IO16","A",400
261: ret
262:
263:
264: "SET CO CONSTANTS":
265: "(DEFAULT)")F$;% "Probe ID"
266: 100)F[7];% "Full Scale Pressure (bar)"
267: 0)F[4];% " Calibration Offset:Pressure (bar)"
268: 0)F[5];% " Calibration Offset:Temperature (deg C)"
269: 1)F[6];% " Calibration Scaling:Conductivity Ratio "
270: F[7]/100/400)F[1];1/4000)F[2];F[6]/160000)F[3]
271: 1023*2048)N[0];2^21)N[1];2^22)N[2];2^22-1)N[3]
272: ret
273:
274:
275: "SET SE CONSTANTS":
276: .008)G[0];-.1692)G[1];25.3851)G[2]
277: 14.0941)G[3];-7.0261)G[4];2.7081)G[5]
278: .0005)H[0];-.0056)H[1];-.0066)H[2]
279: -.0375)H[3];.0636)H[4];-.0144)H[5]
280: .6766097)I[0];2.00564e-2)I[1];1.104259e-4)I[2]
281: -6.9698e-7)I[3];1.0031e-9)I[4]
282: 3.426e-2)J[1];4.464e-4)J[2];.4215)J[3];-3.107e-3)J[4]
283: 2.07e-4)K[1];-6.37e-8)K[2];3.989e-12)K[3]
284: 999.842594)P[0];6.793952e-2)P[1];-9.09529e-3)P[2]
285: 1.001685e-4)P[3];-1.120083e-6)P[4];6.536332e-9)P[5]
286: .824493)Q[0];-4.0899e-3)Q[1];7.6438e-5)Q[2]
287: -8.2467e-7)Q[3];5.3875e-9)Q[4]
288: -5.72466e-3)R[0];1.0227e-4)R[1];-1.6546e-6)R[2]
289: ret
290:
291:
292: "SET PROFILE TRIGGERS":
293: 0)r0;1)r1;3)r2;5)r3;7.5)r4;10)r5;13)r6;16.5)r7;20)r8;25)r9;30)r10
294: 35)r11;40)r12;50)r13;60)r14;75)r15;87.5)r16;100)r17;112.5)r18
295: 125)r19;137.5)r20;150)r21;175)r22;200)r23;250)r24;300)r25
296: 400)r26;500)r27;600)r28;700)r29;800)r30;900)r31;1000)r32
```

```
297: 1100)r33;1200)r34;9999)r35
298: ret
299:
300:
301:
302: "SETUP TAPE DRIVE":
303: "setup":clr "9Tc";rdb("9Tc")}p1
304: if bit(0,p1);beep;ent "Tape is Write-protected",p1;gto "setup"
305: if bit(1,p1);beep;ent "Please select 1600 CPI tape",p1;gto "setup"
306: if bit(5,p1);beep;ent "Please put tape ON LINE",p1;gto "setup"
307: cll 'POSITION TAPE'
308: cmd "9Tc","IM(0) WC(2) BS(3200)"
309: rdb("9Tc")}p1
310: if bit(7,p1);dsp "Tape Error:",band(7,p1);end
311: ret
312:
313: "POSITION TAPE":
314: dsp "Please Stand By"
315: cmd "9Tc","MF(-2)"
316: rdb("9Tc")}p1;cmd "9Tc","FE"
317: "recheck":time 32500;dsp "Please Stand By"
318: on err "TIMEOUT"
319: rdb("9Tc")}p1
320: on err "HPLerr"
321: time 0;if bit(7,p1);dsp "Tape Error:",band(7,p1);end
322: dsp " ";ret
323:
324: "TIMEOUT":
325: if rom#69 or ern#4;gto "HPLerr"
326: ""}Y$;beep;ent "Is this a NEW tape? [y/n]",Y$
327: Y$[1,1]}Y$;if Y$#"y" and Y$#"n";gto -1
328: if Y$="n";gto "recheck"
329: ""}Y$;beep;ent "Please confirm new tape [y/n]",Y$
330: Y$[1,1]}Y$;if Y$#"y" and Y$#"n";gto -1
331: if Y$="n";gto "recheck"
332: time 0;cli "HPIB";cmd "9Tc","RW"
333: dsp "Please Stand By";ret
334:
335:
336: "CHANGE H DATA":
337: for I=1 to 9
338: fxd 0;jmp I
339: 1)p2;99)p3;0)p4;"Ship# ?")Y$;gto "ask"
340: 1)p2;999)p3;0)p4;"Trip# ?")Y$;gto "ask"
341: 1)p2;999)p3;0)p4;"Station# ?")Y$;gto "ask"
342: 1)p2;999)p3;0)p4;"CTD Profile# ?")Y$;gto "ask"
343: 0)p2;89)p3;0)p4;"Lat.(deg) ?")Y$;gto "ask"
344: 0)p2;59.9)p3;-1)p4;"Lat.(min) ?")Y$;fxd 1;gto "ask"
345: 0)p2;99)p3;0)p4;"Long.(deg) ?")Y$;gto "ask"
346: 0)p2;59.9)p3;-1)p4;"Long.(min) ?")Y$;fxd 1;gto "ask"
347: 9)p2;9999)p3;0)p4;"Sounder Depth(m) ?")Y$
348: "ask":dsp Y$&"["&str(A[I])&" ]";ent "",p1;if flg13;A[I])p1
349: prnd(p1,p4)}p1;if p1<p2 or p1>p3;beep;gto -1
350: p1)A[I];next I
351: cll 'CHANGE DATE'(A[10],A[11],A[12])
352: cll 'CHANGE TIME'(A[13],A[14])
353: ret
354:
355: "CHANGE DATE":
356: fmt "Date ? (YYMMDD in GMT) [",3fz2.0,"]"
```

```
357: wrt 0,p1,p2,p3;ent "",p7
358: int(p7/10000)}p4;if flg13;p1}p4
359: int(100frc(p7/10000))}p5;if flg13;p2}p5
360: int(100frc(p7/100))}p6;if flg13;p3}p6
361: if p4<83 or p4>99;beep;gto "CHANGE DATE"
362: if p5<1 or p5>12;beep;gto "CHANGE DATE"
363: if p6<1 or p6>31;beep;gto "CHANGE DATE"
364: p4}p1;p5}p2;p6}p3
365: ret
366:
367: "CHANGE TIME":
368: fmt "Time ? (HHMM in GMT) [",2fz2.0,"]"
369: wrt 0,p1,p2;ent "",p5
370: int(p5/100)}p3;if flg13;p1}p3
371: int(100frc(p5/100))}p4;if flg13;p2}p4
372: if p3<0 or p3>23;beep;gto "CHANGE TIME"
373: if p4<0 or p4>59;beep;gto "CHANGE TIME"
374: p3}p1;p4}p2
375: ret
376:
377: "PRINT H DATA":
378: fmt 16"-",/,"Ship#",f2.0,x,"Trip#",f3.0
379: wrt p1,A[1],A[2]
380: fmt "Station#",f3.0;wrt p1,A[3]
381: fmt "CTD Profile#",f3.0,/;wrt p1,A[4]
382: fmt c6,fz2.0," ",fz4.1,c2
383: wrt p1,"Lat:  ",A[5],A[6]," N"
384: wrt p1,"Long: ",A[7],A[8]," W"
385: fmt /,"19",fz2.0," ",fz2.0," ",fz2.0
386: wrt p1,A[10],A[11],A[12]
387: fmt fz2.0,":",fz2.0," GMT",/
388: wrt p1,A[13],A[14]
389: fmt "Sounding: ",f4.0,"m.";wrt p1,A[9]
390: ret
391:
392:
393: "FILL HEADER BUFFER":
394: "header"}Y$;buf Y$
395: fmt z,f2.0;wrt Y$,A[1]
396: fmt z,2f3.0;wrt Y$,A[2],A[3]
397: fmt z,2f5.0
398: wrt Y$,1000A[5]+10A[6],1000A[7]+10A[8]
399: fmt z,f2.0;for I=10 to 14;wrt Y$,A[I];next I
400: fmt z,f5.0;wrt Y$,10A[9]
401: fmt z,c5;wrt Y$," BCTD"
402: fmt z,f3.0;wrt Y$,A[4]
403: ret
404:
405: "PRINT PROFILE ID":
406: cll 'PRINT H DATA'(6)
407: cll 'PRINT CALIBRATION DATA'
408: fmt /,"   Depth   Temp  Salinity  Sigma-t   Cond Ratio",/,2x,46"-";wrt
409: ret
410:
411: "PRINT CALIBRATION DATA":
412: fmt 20x,"CALIBRATION DATA",/,20x,16"-"
413: wrt 6
414: fmt "Probe ID   FS pressure   P offset   T offset   C scaling"
415: wrt 6
416: fmt c9,4x,f3.0," bar",4x,f5.2," bar",x,f6.3," degC",3x,f8.6,/
```

```
417: wrt 6,F$,F[7],F[4],F[5],F[6]
418: fmt " "
419: wrt 6
420: ret
*3795
```